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Evidence of random walk in Pakistan stock exchange: An emerging stock market study

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Abstract. The study reports the empirical evidence on the presence of weak-form efficiency under the random walk hypothesis on the emerging stock market of Pakistan; Pakistan stock exchange (PSX), formerly known as Karachi stock exchange (KSE) from January 01, 2009 to August 31, 2014, by investigating two categories of stock indices; one in which the selection of firms is based upon market capitalization and the other where the selection criteria of firms is based upon free-float methodology. The study applied both non-parametric and parametric tests; Kolgomorov-Simirnov (K-S), runs, serial correlation and unit root tests on daily returns of KSE-100 index; KSE- all share index; KSE-30 index and KMI-30 index. The study finds absence of random walk on the former two indices, where chronology of firms and selection criteria are based on traditional market capitalization technique. However, evidence of random walk is found in stock-indices where selection of firms is based on free floating methodology. The trace of random walk advocates the free floating methodology over market capitalization criteria.
Keywords. Random walk, Weak-form efficiency, Karachi stock exchange, Pakistan stock exchange, Unit root test, Autocorrelation.
JEL. G10, G12, G14.

1. Introduction

Under the paradigm of efficient market hypothesis (EMH), Fama (1970) identified three degrees of stock market efficiency; strong-form, semi-strong form and weak-form efficiency. Efficiency in the stock market believes random movements in stock prices and precludes persistent abnormal returns with likelihood of market exploitation. Presence of the weakest form of efficiency implies random walk i.e., randomness in price movements. Investigation of which has been a major interest of researchers in the field of economics and finance in wake of the development of financial models and theories. Moreover, the efficiency of capital market is a powerful tool for attracting investors by providing the sense of protection to them; enhances investment and implies positive impacts on economic growth and development. Inefficient market on the other hand may fail to allocate capital efficiently and calls for appropriate reforms by regulatory authorities. Therefore, information about market efficiency has important implications on the portfolio decisions and investment strategies of the investors. Empirical evidence in favour or against EMH can be considered a major

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contribution towards the strategic trading adeptness of a portfolio manager and of a proficient investor.

The efficient market hypothesis became a controversial issue for the empirical evidence against efficiency and seasonal anomalies in the stock market. Supporters of this school of thought (Summers, 1986; Fama & French, 1988; Lo & MacKinlay, 1988; Poterba & Summers, 1988) contradicted random walk characteristic on the basis of certain psychological and behavioral elements and presented evidence against the hypothesis and concluded that stock market returns to a considerable extent are predictable. Contradictory and inconsistent results, even after the extensive published work in this field calls for diversified approaches with innovative methodologies. It is this inconsistency in results that has provided the motivation to conduct a comprehensive study on Pakistan stock exchange (PSX)[i] by applying parametric and non-parametric tests on two sets of indices categorised on the basis of criteria of selection of the firms. This study can be major contribution in the area as until now no study has been conducted to examine the random walk by focusing the selection of firms' criteria. Another notable contribution of the study lies in the fact that a very little empirical work so far is furnished on KSE-30 index, all-share index and KMI-30 index; the indices holding a sizable share in the market. The selection of firms in the various indices can be categorised into two; one in which indices the selection of firms is based upon market capitalization (KSE-100 index and KSE-all share index) and the other where selection of firms is based upon free-float methodology (KSE-30 and KMI-30). Amongst these; KSE-30 was introduced as a benchmark to determine the performance of stock market, KMI-30 consisted of firms which strictly meet the Sharia criteria, and all-share index takes all firms into consideration. The study aims to investigate the stance of random walk, if any, in the two categories of stocks in PSX that may conclude the efficiency of one selection criteria over the other.

2. Literature review

Enormous studies have been conducted since the seminal work of Fama (1965a) to investigate the degrees of efficiency in developed and in emergent markets of the world using various techniques. However, efficient market hypothesis became a controversial issue on the basis of empirical evidence against efficiency and presence of various anomalies in the stock market (Summers, 1986; Fama & French, 1988; Lo & MacKinlay, 1988). Similarly, De Bondt & Thaler (1985; 1987) Barberis *et al.,* (1998) Lehmann (1990) Hong & Stein (1999) revealed an anomaly of random walk in the presence of under and over-reaction of price changes and autocorrelation in the stock markets.

Working (1934), Kendall (1953), Cootner (1962), Lee (1992) and Poon (1996) supported random walk on zero correlation rationale on United States and European developed stock markets. Similarly, Choudhry (1994) examined stock indices of United States, United Kingdom, Canada, France, Japan, Italy and Germany for the period 1953–1989, by applying unit root test and Johansen method of cointegration using monthly return series. Lee *et al.,* (2000) tested French *futures* and *options* markets using unit root and variance ratio tests.

On the other hand, random walk was rejected on the basis of positive serial correlation in the short run and negative autocorrelation in the long run in the developed market of US (Lo & MacKinlay, 1988; Fama & French, 1988; Poterba & Summers, 1986; 1988). On the contrary, Worthington & Higgs (2004) and Borges (2010) examined both developed and emerging European equity markets for random walk using parametric and nonparametric tests and found evidence of random walk in developed countries of Europe. Traditionally markets of developed economies are more efficient as compared to emergent markets (Gupta, 2006).

Mixed results were observed in case of Central and Eastern European financial markets with traces of weak-form efficiency in stock exchanges of Athens and

Turkey (Smith & Ryoo, 2003; Guidi *et al.,* 2011; Kapusuzoglu, 2013; Dragota & Tilica, 2014).

Urrutia (1995), Grieb & Reyes (1999) and Worthington & Higgs (2003) scrutanized Latin Amirican emerging markets and found contradictory results for various test applied.

In case of African American emergent markets the results reveal absences of random walk except for South African markets which were found to follow random walk (Smith *et al.,* 2002; Magnusson & Wydick, 2002; Jefferis & Smith, 2005; Mlambo & Biekpe, 2007; Al-Khazali *et al.,* 2007; Lagoarde-Segot & Lucey, 2008). However, rejection of weak-form efficiency in Botswana stock market was also found very recently when parametric and non parametric (autocorrelation test, Kolmogorov-Smirnov test, runs test, ADF and Phillips-Parron (PP) unit root test) were applied (Chiwira & Muyambiri, 2012).

Random walk was not rejected in the markets of the Middle Eastern countries and evidence reveals that Iranian, Gulf and Saudi Arabia markets are found weak-form efficient when tested for parametric and non-parametric tests on daily, weekly and monthly returns (Abraham *et al.,* 2002; Marashdeh & Shrestha, 2008; Asiri, 2008; Oskooe, 2011; Asiri & Alzeera, 2013).

A great deal of research can be found in Asian emerging markets over last two decades especially after liberalization of financial markets in 1990's, which increased the integration of world markets and huge amount of capital transfer from developed world in emerging markets. However, the markets of Indonesia, Malaysia and Philippines and China showed no traces of efficiency were found even after liberalization of these markets in eighties (Lima & Tabak, 2004; Charles & Darne, 2009; Nikita & Soekarno, 2012). Similarly, rejection of random walk was also found in Asian emergent markets like India, Bangladesh, Srilanka (Poshakwale, 1996; Mobarak & Keasey, 2000; Abeysekera, 2001; Gupta & Basu, 2007; Mobarek *et al.,* 2008). On the other hand Islam & Khaled (2005) applied heteroscedasticity-robust Box-Pierce test which reversed the result presented in the previous studies. Alam *et al.,* (1999) also concluded similar phenomina about Bangaldesh stock market. Similarly, runs test suggested weak-form efficiency in most of the emerging markets (Karemera *et al.,* 1999).

Pakistani stock market has emerged as one of the outperforming markets of South East Asia in the last two decades. After the financial reforms of 1990s the market gained significant amount of capital inflow from developed markets. Several studies have been conducted on efficiency of Karachi Stock Exchange (KSE), which is regarded as the most dynamic and leading stock market of country. But like other markets of South Asia, Pakistani market revealed absence of random walk Uppal (1993), Khilji (1994), Ahmed & Rosser (1995); Husain (1997); Cooray & Wickramasighe (2007); Haque, Liu & Nisa (2011). Similarly in another study Mustafa & Nishat (2007) investigated KSE-100 index for daily, weekly and monthly stock returns for the period 1991-2003 and found the stock market to be efficient after making adjustments for thin trading.

Volatility is highly persistent in KSE-100 index and least persistent in KSE-30 index; two most traded indices of Pakistani stock market (Shamshir & Mustafa, 2014). Seasonal anomalies were also found in the Pakistani stock market (Mustafa & Nishat, 2007; Mustafa, 2011; Shamshir & Mustafa, 2014; Shamshir *et al.,* 2016).

3. Methodology

The main hypotheses of testing random walk and efficiency consist of following null and alternative hypotheses.

H_0 : The stock indices in Pakistan stock exchange follow random walk, i.e., indices in Pakistan stock exchange are weak-form efficient.

H_1: The stock indices in Pakistan stock exchange do not follow random walk, i.e., indices in Pakistan stock exchange are not weak-form efficient.

3.1. Kolgomorov-Simirnov (K-S) test

The test is used to compare the return series with the parameters of uniform and standard normal distribution.

H_0: The returns series follow normal distribution.

H_1: The returns series do not follow normal distribution.

The Kolmogrov-Smirnov (K-S) statistics for a given continuous cumulative distribution function F(x) is given by

$$D_n = Max_x \, |F_n(x) - F(x)| \tag{1}$$

The hypothesis regarding the distributional form is rejected if the test statistics D is > than the critical value obtained from the table. Alternatively, for higher sample size the hypothesis cannot be accepted if probability of K-S statistics is significant at 1% and 5% level of significance.

3.2. Runs test

Runs test is based on the intuition that the residuals of the series show a certain pattern of negative and positive values then the series do not follow random walk and serial correlation exists in the series. Too many runs in a series reflect the frequent sign change in the series indicating negative correlation and too few runs indicate positive correlation.

H_0: The returns series follow random walk

H_1: The returns series do not follow random walk.

$$Z = \frac{A_R - E_R}{\sigma_R} \tag{2}$$

Where, A_R is the actual number of runs, and E_R is the expected number of runs (mean).

$$E_R = \frac{2N_1N_2}{N} + 1 \tag{3}$$

$$\sigma_R^2 = \frac{2N_1N_2(2N_1N_2 - N)}{(N^2)\,(N-1)} \tag{4}$$

Where, N= total number of observations = $N_1 + N_2$

N_1 = number of positive elements (residuals)

N_2 = number of negative elements (residuals)

The series will follow normal distribution the null hypothesis of randomness cannot be rejected then following condition is expected:

Prob $[E_R - 1.96\sigma_R \le A_R \le E_R + 1.96\sigma_R]$ = 0.95

The runs test is based on the hypothesis that if returns are random, the actual number of runs (A_R) should be close to the expected number of runs (E_R)

For larger samples the hypothesis is rejected if at 5% significance level, runs test statistics (Z) with an absolute value is greater than 1.96 and concludes randomness.

3.3. Serial correlation or autocorrelation test

In order to test serial correlation between the current and lagged value stock prices spectral analysis tests and serial correlation test are found in earlier studies as the tools used of testing weak-form efficiency of Morgenstern (1963), and Fama (1965). These statistical procedures are testing the least restrictive version of the random walk hypothesis, which is the Random Walk 3 model of Campbell *et al.*, (1997) that only requires uncorrelatedness of price.

Given a stationary time series of stock returns R_t , the kth order autocorrelation coefficients, $\rho(k)$, expressed as

$$\rho(k) = \frac{\sum_{t=1}^{n-k}(R_t - R_\mu)(R_{t-k} - R_\mu)}{\sum_{t=1}^{n}(R_t - R_\mu)^2} \quad (5)$$

$\rho(k) \sim N(0, 1)$ for random return series.

Where,

ρ_k is the serial correlation coefficient of stock returns of lag *k*; R_t denotes returns at time *t*; R_{t-k} denotes returns over time period *t-k*; and *k* denotes number of lags. The objective is to determine the presence of serial correlation in the series. ρ_k is a unit free measure and lies between -1 and +1. Positive and negative values of ρ_k indicate positive and negative correlation. Positive serial correlation is mean-aversion and reflects slow adjustment to new information due to under-reaction. On the other hand negative serial correlation reflects mean-reversion. Zero correlation means randomness of return series. In case of large samples joint hypothesis of all lag values of autocorrelation coefficient is tested by using Ljung-Box (LB) (Q)statistics, a chi-square distribution with degrees of freedom equal to number of autocorrelation (*k*) is given by,

$$LB(Q) = n(n+2)\sum_{k=1}^{m}\left(\frac{\rho_k^2}{n-k}\right) \quad (6)$$

Empirical evidence suggested using autocorrelation coefficient in conjunction with Ljung-Box statistics to examine serial correlation is most appropriate tool for large sample size (e.g., Laurence, 1986; Poshakwale, 1996; Mobarek *et al.,* 2008; Patel *et al.,* 2012).

H_0: The returns series possesses zero autocorrelation at the first k autocorrelations $(\rho_1 = \rho_2 = \rho_3 = \cdots \rho_k = 0)$

H_1: The returns series does not possess zero autocorrelation at the first k autocorrelations $(\rho_1 \neq \rho_2 \neq \rho_{13} \neq \cdots \rho_k \neq 0)$

For the return series to be stationary with zero autocorrelation the null hypothesis cannot be rejected if all of the autocorrelation coefficients σ_k are zero. However the null hypothesis can be rejected if some ρ_k are non-zero. Conventionally, the probability value of less than 0.05 (at 5% level of significance) that the estimated coefficient of correlation is zero, indicates that the time series exhibits significant autocorrelations.

3.4. Autoregression, heteroscedasticity and Breusch-Godfrey LM test for serial correlation

Ignoring serial correlation in a regression means OLS coefficients may be unbiased and consistent but inefficient and variances of coefficients may be biased forecast is invalid in this case. The Breusch–Godfrey serial correlation LM test is a test for examining autocorrelation in the errors in an autoregressive model. Breusch-Godfrey LM test can be used for AR (1) or AR (p) terms. For the R^2 statistic following asymptotic approximation can be used for the distribution of the test statistic;

$$nR^2 \sim \chi_p^2$$

Assuming an AR(1) model

$$Y_t = \alpha_1 Y_{t-1} + \mu_t \tag{7}$$

If μ_t is first order serially correlated then,

$\mu_t = \rho_1 \mu_{t-1} + \varepsilon_t$, Such that,

$\varepsilon_t \sim iid\ N(0, \sigma^2),\ t = 1,2, \dots .n.$

$H_0 = \rho_1 = 0$

$H_0 = \sigma_1 \neq 0$

3.5. Unit root test

Unit root testing is regarded as a vital tool for determining the presence of random walk in a series. A series is said to have unit root if it is stationary however, stationarity is considered to be an essential but not sufficient condition of presence of the random walk in a series. Presence of unit root implies the presence of predictability in the price or return series, which is not consistent with random walk model as it requires unpredictability in successive prices or in returns. For the series to be stationary , $\rho = 0$, and $\emptyset = 1$.

In general a time series to be tested can assume the following.

$$p_{it} = \emptyset p_{it-1} + \varepsilon_{it} \tag{8}$$

$$p_{it} - p = \emptyset\, p_{it-1} - p + \varepsilon_{it}$$

$$\Delta p_{it} = (\emptyset - 1) p_{it-1} + \varepsilon_{it}$$

$$\Delta p_{it} = \rho p_{it-1} + \varepsilon_{it}$$

Three different tests are being used here namely: the augmented Dickey-Fuller (ADF) test, the Phillips Perron (PP) test and the Kwiatowski, Phillips, Schmidt and Shin (KPSS) test.

3.6. Augmented Dickey-Fuller test

The ADF test is the extended form of Dickey-Fuller (DF) test for determining the unit root in a time series. The difference lies in the consideration of AR(1) process in case of DF while AR(p) process in case of ADF case. The ADF is considered to be more valid where time series is based on daily data as it also involves the lagged difference terms of the dependent variable.

Following equation with drift and trend will be investigated and compared with the critical values of MacKinnon (1994) in order to determine the significance of the t-statistics associated with ρ_0

$$\Delta p_{it} = \alpha_0 + \alpha_1 t + \rho_0 p_{it-1} + \sum_{i=1}^{q} \rho_i\, \Delta p_{it-i} + \varepsilon_{it} \tag{9}$$

Where,

Δp_{it} is the first difference of the log of the closing price index of *ith* index /firm and selected firm.α_0 is the constant of drift parameter. $\alpha_0 t$ is the coefficient of trend. ρ_0 is the coefficient of AR(1) term. ρ_i are the coefficient of lagged terms and *q*, is the number of lagged terms, and ε_{it} is white noise. The null hypothesis for non- stationary series is as follows.

$H_0: \rho = 0$, series has unit root

$H_a: \rho < 0$, no unit root

Failing to reject null hypothesis implies that time series possesses the properties of random walk.

3.7. Phillips-Parron (PP) test

Phillips & Parron (1988) introduced this particular test for the analysis of unit root in a time series. The test is non-parametric in nature and accounts for antocorrelation without adding lagged differences in the regression.

The regression equation for the test is given by:

$$\Delta p_t = \alpha_0 + \alpha_1 t + \theta p_{t-1} + \varepsilon_t \tag{10}$$

The ε_t in this case may be heteroscedastic. The PP test corrects for any serial correlation and heteroscedasticity present in ε_t. Two statistics are to be analyzed in this case

$$z_t = \left(\frac{\sigma^2}{\lambda^2}\right)^{1/2} . t_{\theta=2} - \frac{1}{2}\left(\frac{\lambda^2 - \sigma^2}{\lambda^2}\right) . \left(\frac{T.\ SE(\theta)}{\sigma^2}\right) \tag{11}$$

$$Z_\theta = T\theta - \frac{1}{2}\frac{T^2\, SE(\theta)}{\sigma^2}\left(\lambda^2 - \sigma^2\right) \tag{12}$$

The terms σ^2 and λ^2 are estimates of variance parameters.

$H_0: \theta = 0$, series has unit root

$H_1: \theta \neq 0$, series has not unit root

3.8. The Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test

Unlike the PP test it is a parametric test and has a null hypothesis assuming stationarity of a time series around mean or a linear trend. The alternative hypothesis assumes the presence of unit root. The KPSS model assumes the combination of deterministic trend $\mathcal{D}t$, a random walk $\mathcal{R}_t$and an error term ε_t.

$$p_t = \mathcal{D}t + \mathcal{R}_t + \varepsilon_t \tag{13}$$

$$\mathcal{R}_{t=} \mathcal{R}_{t-1} + u_t \tag{14}$$

$p_t, t = 1,2,3 \ldots . T$ time series of stock prices from $t = 1$ till time T, t is the deterministic trend, $\mathcal{R}_t$ is the random walk process and ε_t is the error term of equation 1. u_t is the error term of equation 2, such that $u_t \sim iid.$

In case of $\sigma_u^2 = 0,$ of random walk process $\mathcal{R}_t$, the series is assumed to be stationary. In case if $\mathcal{D} = 0$, the null hypothesis means that series is stationary around $\mathcal{R}_0$. On the other hand $\mathcal{D} \neq 0$, reflects stationarity around linear trend. Variance $\sigma_u^2 > 0,$ implies that the series is non-stationary around trend and random walk.

$H_0: \sigma_u^2 = 0$, series is stationary and has no unit root.

$H_1: \sigma_u^2 > 0$, series is non-stationary and has unit root

The test statistics is defined by one sided Lagrange Multiplier given as:

$$LM = \frac{\sum_t^T S_t^2}{\sigma_t^2} \tag{15}$$

Where,

$S_t = \sum_{i=1}^{t} e_i$, for $t = 1,2, \ldots T$, is the partial sums of errors.

e_t, $t = 1,2, \ldots T$ denote estimated errors from regression of p_t on constant and time, σ_t^2, denotes the estimate of variance.

4. Analysis and results

Table-1 exhibits the summary of descriptive statistics of the returns of KSE-100, KSE-30, KSE-all share and KMI-30 index from Jan, 2009-Aug 2014. The mean returns of all four indices are positive reveal capital gains in the market over the period. The standard deviation of KSE-30 index is highest (0.4569) reflects the volatility and huge deviation from mean returns in KSE-30 index. For KSE-100 standard deviation are very small, showing less dispersion in the maximum and minimum values of stock prices reflects less volatility in the stock returns.

Table 1. *Descriptive Statistics of Daily Returns of PSX Indices*

	KSE-100	KSE-ALL	KSE-30	KMI-30
Obs	1404	1403	1404	1402
Mean	0.00112	0.00110	0.02206	0.00138
Std. Deviation	0.01106	0.01720	0.45694	0.04291
Skewness	-0.168	-0.831	21.537	0.334
Kurtosis	5.762	273.089	463.239	369.719
JB	451.40	4328733.00	12545525.00	7894230.00
CV	9.893	15.675	20.711	30.989

The values of skewness greater than zero value in return series of all indices shows asymmetry in the returns with negative skewness in KSE-100 and KSE-all indicates greater probability of large decreases in returns than rises, while positive skewness in KSE-30 and KMI-30 index reveals increases in returns. Similarly, higher than zero value of JB test reflects deviations from normal behaviour of return series during the study period in all four indices. The coefficient of variation is lowest in case of KSE-100 index indicating it as least volatile index.

Table-2 and 3 explain the result of K-S Goodness of fit test to examine the cumulative distribution function of the return series of the indices and selected firms of Pakistan stock exchange for normal and uniform distribution parameters, respectively. The probabilities of K-S Z statistics for both normal and uniform distribution are zero (0.000), indicating that at 1% level of significance the hypothesis can be rejected, concluding that the indices of Pakistan stock exchange under study time period do not follow uniform and normal distribution. Higher values of KS-Z test reflect greater deviations from normal distribution in KSE-30, KMI-30 indices.

Table 2. *Kolmogrov Smirov Test on Daily Returns of PSX Indices with Normal Distribution*

		KSE-100	KSE-ALL	KSE-30	KMI-30
Normal	Mean	0.001	0.001	0.022	0.001
Parameters	Std. Deviation	0.011	0.017	0.457	0.043
Most	Absolute	0.069	0.167	0.474	0.291
Extreme	Positive	0.069	0.163	0.474	0.283
Differences	Negative	-0.069	-0.167	-0.441	-0.291
KS-Z Test		2.601	6.254	17.777	10.906
Asymptotic (2-tailed)		0	0	0	0

Table 3. *Kolmogrov Smirov Test on Daily Returns of PSX Index with Uniform distribution*

Index		KSE-100	KSE-30	KSE-ALL	KMI-30
Uniform	Minimum	-0.051	-0.341	-0.366	-0.937
Parameters	Maximum	0.053	9.898	0.354	0.945
Most	Absolute	0.293	0.959	0.457	0.475
Extreme	Positive	0.286	0.959	0.443	0.475
Difference	Negative	-0.293	-0.027	-0.457	-0.471
K-S Z Test		10.974	35.909	17.122	17.768
Asymptotic (2-tailed)		0	0	0	0

Results of runs test reveal (Table 4) that in KSE-100, KSE-30, KSE all-share and in KMI-30 indices at 5% level of significance the value of Z-statistics (-2.857,-6.082,-2.911,-2.326, respectively) with an absolute value greater than 1.96, leads to rejection of null hypothesis. Moreover, the observed number of runs is fewer than the expected runs which indicate the presence of negative autocorrelation (Guidi, Gupta & Maheshwari, 2011). Negative autocorrelation indicating the over-reaction in the indices (De Bondt & Thaler 1985; 1987) vis-à-vis in the Pakistan stock market and establishes the absence of randomness with mean aversion characteristic. This shows the affinity of over-reaction to unanticipated and shocking news in all four indices. It can be concluded from the results of runs test that prices do not move independently and randomly and the Pakistan stock market under the study period does not follow random walk. It is inferred the some investors can make excess profits in the said market by taking advantage of over-reaction to stirring and unanticipated information. Similar results found were in the previous studies for Pakistan (Ahmad & Rosser, 1995; Abraham, Seyyed, & Alsakran, 2002; Abeysekera, 2001; Mustafa, 2007; Mishra, 2011; Haque, Liu & Nisa, 2011).

Table 4. *RUNS Test on Daily Returns of PSX Indices*

	KSE-100	KSE-ALL	KSE-30	KMI-30
Test Value	0.0012	0.0011	0.0221	0.0014
Cases < Test Value	703	700	1329	740
Cases >= Test Value	701	703	75	662
Total Cases	1404	1403	1404	1402
Number of Runs	649	648	120	656
Z	-2.883	-2.911	-6.086	-2.349
Asymptotic (2-tailed)	.004	.004	.000	.019

The autocorrelation coefficients have been computed for the return series in the indices of Pakistan stock exchange and found significant autocorrelation at various lags for the whole sample period. Table 5 exhibits highest correlation coefficient in first lag in all four indices However, zero correlation coefficient at various lags in few firms and in KSE-30 and KMI-30 indices indicating randomness at this lag. In KSE-30 zero correlation coefficient is found from lag 3 to 7, 17 to 20, and 25 to 34 indicating no autocorrelation in these lags. It can be concluded that return series is random and future returns cannot be predicted in these lags. Similarly, KMI-30 shows absence of autocorrelation at lags 14, 15, 17, 20 and 30. Both negative and positive correlation can be found in all four indices. The results can be compared to the evidences collected for the emergent and developed markets. Claessens, Susmita, and Jack (1995) found the first-order autocorrelation greater than 0.2 in most of the emergent markets including Pakistan, while for developed economies it is generally not higher than 0.2. However, the result is consistent in case KSE-30, KSE-all, KMI-30.

Table 5 also presents the result of the ACF and LB statistics for the daily returns on the KSE-100, KSE all-share, KSE-30 and KMI-30 indices of Karachi stock exchange. To test for the serial correlation in these markets under study period autocorrelation test up to 36 lags were performed for daily stock returns. The evidence from Ljung-box statistics also provides the possibility dependency of future returns to past returns. The rejection of null hypothesis is based on the condition that if p-value is significant at 1% and 5% (p-value < 0.05). Result from table 4 shows that null hypothesis cannot be accepted and it can be concluded from the autocorrelation coefficient and Ljung-box statistics that Pakistan stock market under the study period shows significant autocorrelation in the indices and absence of random walk. However, there is zero correlation evident at various lags of KMI-30 index which is attributed to free-floating nature of shares in these two indices. As evident from the table-5 negative autocorrelation in Pakistan stock market suggests the over-reaction to unexpected news and information seems to be the strategy to earn above normal returns. The investors adopt mean reversion strategy of buying the stocks which had lower returns in the past in the expectations of higher returns today and selling the stocks having higher returns previously in expectations of lower returns in future.

Table 5. *Autocorrelation Test on Daily Returns of PSX Indices.*

	KSE-100			KSE-30			KSE-All			KMI-30		
	Coeff	Ljung Box	Prob	Coeff	Ljung Box	Prob	Coeff	Ljung Box	Prob	Coeff	Ljung Box	Prob
L1	.105	15.38	.000	.665	621.32	.000	-.286	115.06	.000	-.459	295.50	.000
L2	.041	17.69	.000	.332	776.82	.000	.021	115.66	.000	-.001	295.50	.000
L3	.012	17.90	.000	.000	776.82	.000	-.025	116.53	.000	.006	295.56	.000
L4	.043	20.53	.000	.000	776.82	.000	.035	118.22	.000	-.001	295.56	.000
L5	.007	20.60	.001	.000	776.82	.000	.002	118.22	.000	-.004	295.58	.000
L6	.030	21.83	.001	.000	776.82	.000	.033	119.81	.000	.005	295.62	.000
L7	-.021	22.45	.002	.000	776.82	.000	.001	119.81	.000	-.003	295.63	.000
L8	-.044	25.13	.001	.001	776.83	.000	.011	119.99	.000	-.005	295.67	.000
L9	-.011	25.30	.003	-.001	776.83	.000	-.060	125.09	.000	-.001	295.67	.000
L10	.057	29.92	.001	-.002	776.83	.000	.075	132.98	.000	-.002	295.68	.000
L11	-.014	30.21	.001	-.002	776.83	.000	-.024	133.80	.000	.002	295.68	.000
L12	-.009	30.33	.002	.000	776.83	.000	-.020	134.37	.000	.006	295.73	.000
L13	-.010	30.48	.004	.000	776.83	.000	-.012	134.59	.000	-.003	295.75	.000
L14	-.005	30.52	.006	-.001	776.84	.000	.026	135.56	.000	.000	295.75	.000
L15	.029	31.70	.007	-.001	776.84	.000	-.014	135.84	.000	.000	295.75	.000
L16	.006	31.76	.011	-.001	776.84	.000	.025	136.69	.000	.003	295.76	.000
L17	-.051	35.46	.005	.000	776.84	.000	-.014	136.99	.000	.000	295.76	.000
L18	.007	35.54	.008	.000	776.84	.000	-.001	136.99	.000	-.008	295.84	.000
L19	-.008	35.63	.012	.000	776.84	.000	-.010	137.14	.000	.004	295.86	.000
L20	-.003	35.64	.017	.000	776.84	.000	.011	137.32	.000	.000	295.86	.000
L21	-.009	35.76	.023	.001	776.84	.000	-.020	137.89	.000	-.008	295.96	.000
L22	-.002	35.77	.032	.001	776.84	.000	.001	137.89	.000	.007	296.02	.000
L23	-.062	41.27	.011	.000	776.84	.000	-.018	138.37	.000	-.010	296.16	.000
L24	-.004	41.30	.015	.001	776.84	.000	.000	138.37	.000	.006	296.20	.000
L25	.021	41.93	.018	.000	776.84	.000	.013	138.61	.000	.006	296.25	.000
L26	.007	42.00	.025	.000	776.84	.000	.004	138.64	.000	-.008	296.35	.000
L27	-.025	42.87	.027	.000	776.84	.000	-.041	141.02	.000	.014	296.63	.000
L28	.014	43.16	.034	.000	776.84	.000	.017	141.43	.000	-.005	296.67	.000
L29	.039	45.36	.027	.000	776.84	.000	.013	141.67	.000	.007	296.73	.000
L30	.063	51.13	.009	.000	776.84	.000	.031	143.09	.000	.004	296.76	.000
L31	-.011	51.30	.012	.000	776.84	.000	-.003	143.10	.000	.000	296.76	.000
L32	-.044	54.13	.009	.000	776.84	.000	-.013	143.34	.000	-.002	296.77	.000
L33	-.063	59.81	.003	.000	776.84	.000	-.017	143.78	.000	-.016	297.13	.000
L34	.012	60.01	.004	.000	776.84	.000	-.002	143.79	.000	.001	297.13	.000
L35	-.002	60.02	.005	.001	776.84	.000	.003	143.80	.000	.004	297.15	.000
L36	-.052	63.86	.003	.001	776.84	.000	-.024	144.65	.000	-.005	297.19	.000

Table 6 exhibits the results of autoregression, White noise test for heteroscedasticity and B-G serial correlation test. The result indicates that most of the return series exhibit autoregression. The value of the coefficient is significantly different from zero at 5% or less level. The test is followed by the White noise test for heteroscedasticity and B-G serial correlation test. The results in table-6, implies the rejection of null hypothesis and so does the presence of random walk for the exchange during the study period. The results are consistent with other emergent markets and previous studies of Pakistan (Mobarak *et al.,* 2008; Mustafa & Nishat, 2007).

Table 6. *Autoregression model, Heteroscedasticity and Breusch-Godfrey Serial Correlation LM test on Daily Returns of PSX Indices.*

				Heteroscedasticity		LM ARCH Test	
		Constant	AR(1)	White noise-stat	Prob.	Q-statistics	Prob.
	Coeff	0.001	0.104				
	t-statistics	3.477	3.897				
KSE-100	P-value	0.001	0	62.592	0	201.518	0
	Coeff	0.001	-0.286				
	t-statistics	3.227	-11.175				
KSE-ALL	P-value	0.001	0	297.885	0	363.235	0
	Coeff	0.007	0.665				
	t-statistics	0.815	33.274				
KSE-30	P-value	0.415	0	167.293	0	249.792	0
	Coeff	0.002	-0.459				
	t-statistics	1.957	-19.295				
KMI-30	P-value	0.051	0	166.703	0	166.118	0

Table-7 shows the results of ADF test at level and at first difference conducted on stock indices to examine the stationarity in stock price series. A series is said to be have unit root if it is stationary. Rejection of null hypothesis of unit root is a condition conducive for the presence of random walk in a series. The ADF statistics fail to reject the null hypothesis of unit root in Pakistan stock market thereby indicating absence of random walk in KSE-100 and KSE all-share. However, in KSE-30, KMI-30, the null hypothesis is rejected and tendency of randomness in prices is evident. It can be concluded that the free floating nature of the indices may be partly responsible for the affinity of randomness of returns.

Table 7. *Augmented Dickey-Fuller Test on Daily Returns of PSX Indices*

	ADF	Level	1st diff
KSE-100	t-stat	-33.660	-22.152
	Prob	0.000	0.000
KSE-ALL	t-stat	-32.055	-21.475
	Prob	0.000	0.000
KSE-30	t-stat	-0.446	-46.711
	Prob	0.899	0.000
KMI-30	t-stat	-23.671	-18.249
	Prob	0.000	0.000

Table 8 shows the results of PP test at level and at first difference for the determination of presence of unit root on the stock return series. If the PP test statistics exceeds the critical values of test it would entail the rejection of null hypothesis of presence of unit root and random walk. The stock prices of KSE-30 and KMI-30 reject the null hypothesis at 5% and 1% respectively, showing signs of random walk in these stock returns. The results are consistent with ADF results.

Table 8. *PP and KPSS Tests on daily Returns of PSX*

	PP Level		PP Difference		KPSS Level	KPSS diff.
	t-stat	Prob	t-stat	Prob	LM stat	LM stat
KSE-100	-2.499	0.329	-33.792	0.000	0.569	0.065
KSE-ALL	-2.256	0.458	-50.660	0.000	0.707	0.051
KSE-30	-3.678	0.024	-44.394	0.000	0.363	0.085
KMI-30	-9.695	0.000	-100.309	0.000	0.272	0.107

However, at difference the returns show nonappearance of unit root. The KPSS assumes the null hypothesis of no unit root. Rejection of null hypothesis implies the non-stationary series and presence of random walk. The null hypothesis is rejected for KMI-30 index at 1% or at higher level of significance. The result shows consistency with other two test of examining unit root and no unit root exists at difference.

5. Summary and conclusion

This particular research is a methodological triangulation [ii] and aimed at investigating weak-form efficiency within the frame work of random walk, in Pakistan stock market previously known as Karachi stock market by examining four major indices, based on market capitalization criterion and free floating criterion by using the data set from January 01, 2009-August 31, 2014. For examining random walk, both non-parametric (K-S, runs) and parametric test (serial correlation, ADF, PP and KPSS, AR models) are employed on the return series of indices.

Results of descriptive statistics reveal that all of the return series tested have positive and negative mean values and do not follow normal distribution with skewed tails on both sides and leptokurtic (positive excess kurtosis) peaks. Non-parametric K-S further confirms that series do not follow of normal distribution. The test also verifies the same for uniform distribution. The results of runs test show the affinity of over-reaction in indices implies spontaneous reaction to unanticipated and shocking news, concluding the absence of random walk in all four indices.

Autocorrelation test and LB statistics reaffirms the rejection of random walk on the return series with evidences of both negative and positive autocorrelation. In case of KSE-30 and KMI-30 under-reaction is found and over- reaction seems to be the dominant strategy to earn abnormal returns for KSE-100 and all-share index. Autoregression test complemented by heteroscedasticity and LM test further ascertain the absence of random walk by rejecting the hull hypothesis of random walk.

On the contrary, KSE-30, KMI-30 revealed evidences of random walk when tested for the presence of unit root by employing ADF, PP and KPSS tests.

Table-9 provides summary of the results found in the study for the detection of random walk among the indices. It can be found that KSE-100 and KSE-all share indices reject the random walk hypothesis while KSE-30 and KMI30 indices found to have no unit root. Similarly, zero autocorrelation was found in KSE-30 for various lags. Therefore, tendencies of random walk can be concluded in these two indices. The credit may be attributed to free floating methodology adopted of shares in these indices. The results of this study are coherent with the previous findings of calendar anomalies in KSE-30 and KMI-30 indices (Shamshir & Mustafa, 2014a; 2016).

Table 9. *Summary of the results on KSE for investigating Random Walk*

Indices	Runs Test	Auto-correlation	LB Stat	Hetero-Scedasticity	LM Test	ADF Level	PP Level	KPSS Level
KSE-100	-	-	-	-	-	-	-	-
KSE-30	-	-	-	-	-	RW	RW	-
KSE- All	-	-	-	-	-	-	-	-
KMI-30	-	-	-	-	-	RW	RW	RW

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Notes

[i] Stock Exchange operations of Karachi Stock Exchange Ltd., Islamabad Stock Exchange Ltd., and Lahore Stock Exchange Ltd. have been integrated and Pakistan Stock Exchange (PSX) came into being w.e.f. January 11, 2016.

[ii] Denzin (1984) identified four types of triangulation approaches: *Data source triangulation*, when the researcher looks for different data to remain the same in different contexts; *Investigator triangulation*, when several investigators examine the same phenomenon; *Theory triangulation*, when investigators with different viewpoints interpret the same results; and *Methodological triangulation*, when one approach is followed by another, to increase confidence in the interpretation.

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